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14. ABSTRACT A partial test model of training performance variability was conducted. The current study examined variability in cognitive ability and training performance in job-specific training. Several studies have found mean score differences in cognitive ability across jobs. Further, the variability in training outcomes among individuals within a job has been shown to vary across jobs. Reduced variability in training outcomes is a measure of training effectiveness. For this study data were grouped by job over several years. Participants were 116,310 enlistees enrolled in 108 US Air Force training specialties. Aptitude was measured by a verbal/math composite derived from the US military enlistment test, the Armed Services Vocational Aptitude Battery. Training performance was assessed by written tests of job-related knowledge content. Predictive validity of the verbal/math composite ranged from .124 to .836 across jobs with a mean weighted value of .691. Substantial differences were observed for mean and variability of aptitude across jobs. Trainees in jobs with high aptitude requirements had higher mean aptitude and were less variable on aptitude than those in jobs with lower aptitude requirements. Further, trainees in high aptitude jobs had higher mean training performance scores and were less variable on performance than those in jobs with lower aptitude requirements. Finally, training performance was much less variable than aptitude. Training had the effect of reducing variability among trainees within jobs. This has the effect of producing a more homogenous set of trainees on trained content, which is beneficial to on-the-job training. Support was found for a part of the test model.					
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7. Performing Organizations

Thomas R. Carretta
Air Force Research Laboratory
711 HPW/RHCI
2210 8th Street
Area B, Bldg. 146, Room 122
Wright-Patterson AFB, OH 45433-7511

Malcolm James Ree
Department of Leadership Studies
School of Business and Leadership
Our Lady of the Lake University
San Antonio, TX 92097

Mark S. Teachout
H-E-B School of Business and Administration
University of the Incarnate Word
4301 Broadway, CPO491
San Antonio, TX 78209

Training Affects Variability in Training Performance Both Within and Across Jobs

Thomas R. Carretta*, Malcolm James Ree**
and Mark S. Teachout***

*Air Force Research Laboratory, Wright-Patterson AFB, OH, USA. thomas.carretta@us.af.mil

**Our Lady of the Lake University, San Antonio, TX, USA

***University of the Incarnate Word, San Antonio, TX, USA

A partial test of a model of training performance variability was conducted. The current study examined variability in cognitive ability and training performance in job-specific training. Several studies have found mean score differences in cognitive ability across jobs. Further, the variability in training outcomes among individuals within a job has been shown to vary across jobs. Reduced variability in training outcomes is a measure of training effectiveness. For this study data were grouped by job over several years. Participants were 116,310 enlistees enrolled in 108 US Air Force training specialties. Aptitude was measured by a verbal/math composite derived from the US military enlistment test, the Armed Services Vocational Aptitude Battery. Training performance was assessed by written tests of job-related knowledge content. Predictive validity of the verbal/math composite ranged from .124 to .836 across jobs with a mean weighted value of 0.691. Substantial differences were observed for mean and variability of aptitude across jobs. Trainees in jobs with high aptitude requirements had higher mean aptitude and were less variable on aptitude than those in jobs with lower aptitude requirements. Further, trainees in high aptitude jobs had higher mean training performance scores and were less variable on performance than those in jobs with lower aptitude requirements. Finally, training performance was much less variable than aptitude. Training had the effect of reducing variability among trainees within jobs. This has the effect of producing a more homogenous set of trainees on trained content, which is beneficial to on-the-job training. Support was found for a part of the model.

1. Introduction

Several empirical studies have found mean score differences in cognitive ability across jobs (Hoffman, 1995; Hunter, 1983; Jensen, 1998; Linn, Harnisch, & Dunbar, 1981; Sackett & Ostgaard, 1994; Schmidt, Ones, & Hunter, 1992). Others have noted that the variability of cognitive ability among individuals within occupations varies across occupations (Jensen, 1980, 1998). Jensen (1998) noted a negative correlation between the means and standard deviations (SD) of IQ

scores across occupations. That is, the higher the mean IQ score for an occupation, the lower the variability of IQs within the occupation. Job incumbents in high aptitude jobs tend to be less variable on cognitive ability than those in lower aptitude jobs. Further, Jensen (1998) noted that “high IQs are found in almost every occupation, but the lowest IQ found in each of the various occupations rises markedly, going from lower to higher occupation levels” (p. 293).

Ackerman (1987) proposed that training may make individuals more homogeneous in performance of tasks that have consistent demands. Alliger and Katzman (1997) speculated that this may occur because although individual differences in cognitive ability contribute to initial differences in task performance, practice decreases cognitive

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demands for repeated tasks resulting in similar levels of performance for most people. In addition, Alliger and Katzman noted that for the most part, studies of training effectiveness focus on the examination of mean performance such as pre- and post-training measures of job knowledge or task proficiency. Alliger and Katzman argued that another important consequence of training is to reduce the variability of task performance, particularly for basic or frequently performed tasks.

Alliger and Katzman (1997) proposed a model to account for the variability of training performance. The model included task characteristics, characteristics of measures, individual differences in ability, individual differences in learning-relevant abilities, and type of training. The current study sought to test a portion of that model. Specifically, we tested the hypothesis that task characteristics, as measured by ability requirements, are related to training variability. These aptitude requirements encompass both individual differences in ability and individual differences in learning-relevant abilities. Further, the aptitude means serve as proxies for job difficulty. The other parts of the model, characteristics of measures, and type of training are constant across the training situations.

2. US military training

Recruitment of job applicants in the private sector often focuses on applicants that already possess job-related knowledge, skills, and abilities acquired through education, training, and job experience. However, few US military enlisted jobs require any specialized training or educational achievement prior to enlistment. Personnel measurement, selection, and classification focus on assessment of trainability. Applicants are selected based on aptitude, then assigned to job-specific training. Although minimum aptitude requirements vary by training specialty, all specialties have some high aptitude trainees. The US military enlistment test battery, the Armed Services Vocational Aptitude Battery (ASVAB; Segall, 2004) assesses general cognitive ability, verbal, math, spatial, and technical knowledge (mechanical, electronics, auto/shop). The ASVAB verbal/math composite, the Armed Forces Qualification Test (AFQT), is a good measure of general cognitive ability (Herrnstein & Murray, 1994; Ree & Earles, 1991). Military applicants are assigned to training specialties based on aptitude, interests, availability of training assignments, and needs of the military. Military training is highly structured with detailed course syllabi, learning objectives, and performance criteria. Military jobs vary in both cognitive complexity and minimum aptitude requirements (Burtch, Lipscomb, & Wissman, 1982; Davis, 1989; Garcia, Ruck, & Weeks, 1985; Weeks, 1984).

3. Purpose

The purpose of this study was to examine variability in training performance in job-specific training for several jobs and also to provide a partial test of the Alliger and Katzman (1997) model of training performance variability. It also studied variability in cognitive ability across jobs. Based on the published literature, training performance was expected to be less variable for those in high aptitude requirement jobs than for those in lower aptitude requirement jobs. Additionally, we expected to find variability differences in cognitive ability across jobs. Cognitive ability scores of trainees in jobs with high aptitude requirements were expected to be less variable than those for trainees in jobs with lower aptitude requirements. Further, training performance also was expected to be less variable than aptitude as a consequence of training.

4. Methods

4.1. Participants

Participants were 116,310 enlistees enrolled in 108 US Air Force training specialties. Sample sizes by training specialty ranged from 85 (Cryptologic-linguist – Spanish) to 19,040 (Security Forces) with a mean and median sample size of 1,077 and 499 across jobs. They qualified for military enlistment based on scores on the AFQT composite,¹ which combines the ASVAB verbal and math tests. Participants qualified for their training specialty based on scores on four ASVAB aptitude composites known as MAGE (Mechanical, Administrative, General, and Electronics).

4.2. Measures

4.2.1. Armed Services Vocational Aptitude Battery

The ASVAB (Segall, 2004) is used for enlistment qualification and classification into training specialties by all branches of the US military. It consists of nine tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Auto and Shop Information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), Electronics Information (EI), and Assembling Objects (AO). The two verbal (WK, PC) and two math (AR, MK) tests contribute to the AFQT composite, which is used by all branches of the US military for enlistment qualification. Each military service branch creates its own set of aptitude composites used to qualify enlistees for training in military specialties. The US Air Force uses four classification composites: Mechanical (M), Administrative (A), General (G), and Electronics (E).² The ASVAB has been validated for training (Carretta, 2014; Ree & Earles, 1991) and job performance (Ree, Earles, & Teachout, 1994).

4.2.2. Training grades

Training grades were comparable across courses. Training performance for each course was reported as the mean percent correct for all written tests completed during training. The minimum passing score for most courses is 70%, although a few courses have higher minimum passing grades. Training grades were available only for those who successfully completed training.

4.3. Analyses

Analyses began with examination of the predictive validity of the AFQT versus training grades. Separately for each training specialty, data were corrected for range restriction using the multivariate method (Lawley, 1943). Mean weighted predictive validity was examined across all jobs and within broad occupational groups (MAGE). Next, mean and variability of aptitude (AFQT score) and training performance (Percent Correct score) was examined by job-specific training course. Data for each course were aggregated across several years. The data were weighted by the sample sizes for the training courses when aggregated results were computed. Variability was assessed in two ways by computing the *SD* and the coefficient of variation (*CV*) of the scores. The *CV* is usually expressed as a percentage ([mean/*SD*] times 100). The *CV* was used because the scores for the measures of aptitude (AFQT) and training performance (Percent Correct score) are on different scales (have different means and *SD*s). *SD* is an absolute measure of dispersion and is in the metric of units of the measures; in this case, the percentile metric of the AFQT and the percent correct metric of the training grades. The *CV* provides a relative measure of dispersion. Using *CV* within training specialties enabled us to examine whether variability of trainees across training specialty changed as a result of training. It also allowed for the comparison of aptitude and training grades on the *CV* indexes which are without metrics.³ Next, correlations were computed for AFQT mean and *SD*, Percent Correct mean and *SD*, and AFQT and Percent correct *CV*s. We focused on the magnitude of the *CV* as the very large sample size leads to high levels of statistical significance.

5. Results and discussion

5.1. Predictive validity

After correction for range restriction (Lawley, 1943), the predictive validity of the AFQT ranged from .124 to .836 across training specialties. The mean validity weighted by sample size was 0.691. Weighted mean predictive validities were similar for Mechanical ($M = 0.684$), General ($M = 0.701$), and Electronics ($M = 0.706$) jobs, but lower for Administrative ($M = 0.618$) jobs. Administrative jobs have lower minimum aptitude requirements and this validity finding is consistent with the extant literature.

It also should be noted that the variability of the predictive validity of the AFQT varied across job groups. The greatest AFQT variability in validity occurred for jobs in the General group ($SD = .103$). The other three job groups had similar levels of variability in AFQT validity (SD ranged from .059 to .070).

5.2. Mean and variability of aptitude and training performance

As shown in Table 1, the weighted mean for aptitude as measured by the AFQT ($M = 68.31$) was about 0.65 *SD* above the mean in the applicant population ($M = 50$, $SD = 28.29$) and the weighted AFQT variability for the trainees ($SD = 13.86$) was well below the population value ($SD = 28.29$) ($(13.86/28.29)^2 = 24\%$). The elevated mean and reduced variability of the trainees compared to the population norms were the consequence of selection on the ASVAB.

Mean aptitude varied substantially across enlisted training specialty. Mean aptitude as measured by the AFQT ranged from 52.28 to 93.37. Mean aptitude varied across broad occupational groups. On average, aptitude was highest for E jobs (weighted $M = 67.6$) and lowest for A jobs (weighted $M = 42.0$), which reflected differences in minimum aptitude requirements for jobs in occupational groups. This was consistent with prior studies showing differences in aptitude across occupations (Hoffman, 1995; Hunter, 1983; Jensen, 1980, 1998; Linn et al., 1981; Sackett & Ostgaard, 1994; Schmidt et al., 1992). Further, variability of mean aptitude within training specialties also varied substantially across specialties, ranging from 4.33

Table 1. Means and standard deviation for study variables

Variable	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
AFQT mean	68.31	8.69	52.28	93.37	0.52	-.36
AFQT SD	13.86	1.86	4.33	16.61	-1.83	4.24
% Corr. mean	87.81	2.92	81.93	96.54	-.31	-.24
% Corr. SD	5.20	0.88	2.60	12.80	0.70	9.77
AFQT CV	20.84	4.52	4.64	27.02	-.98	.42
% Corr. CV	5.96	1.15	2.70	15.21	0.60	7.03

Note: $N = 116,310$.

to 16.61. This also was consistent with the published literature (Jensen, 1980, 1998).

Mean training performance within specialty ranged from 81.93 to 96.54, with a weighted mean across specialties of 87.61. As expected, variability in training performance was smaller within specialty ($SD = 2.92$) than across specialties ($SD = 5.20$).

Comparisons of the relative variability of aptitude (AFQT) and training performance revealed that aptitude was much more variable than training performance ($CV = 20.84$ vs. 5.96). Due to the very large sample size, this difference in CVs was highly significant ($t(116,309) = 1,238.2, p \leq .001$). The much greater kurtosis for training CV at 7.04 versus AFQT CV at .42 echoes this. As suggested by Ackerman (1987) and Alliger and Katzman (1997), training may have reduced variability in knowledge of trained content. It is interesting to note that regardless of the minimum aptitude requirement for a training specialty, all specialties had some trainees with very high aptitude scores (AFQT scores between 95 and 99). This was consistent with Jensen, (1998, p. 293) who observed that high IQs are found in almost every job. Contrary to Jensen, however, most of the military jobs had at least a few individuals with low aptitude. The exceptions were jobs with very high aptitude requirements (e.g., cryptologic-linguist, airborne intel surveillance and reconnaissance, optometry). Even though most jobs had some trainees with lower aptitude, generally there were fewer with lower aptitude as aptitude requirements increased. This later point may be inferred from the strong correlation of the AFQT mean and SD . With a very high mean AFQT score, (for example 93 and a SD of 8), it is unlikely to find AFQT scores much below 75. The

occurrence of high aptitude trainees in all specialties may be a consequence of trainee career preferences, availability of training opportunities at the time of enlistment, or desire on the part of Air Force career field managers to have some high aptitude personnel in all career fields with the potential for promotion and leadership. It may be that career field managers believe the presence of some high aptitude personnel in each training specialty is important to enable sustained effectiveness of the career field.

Analyses conducted by broad job groups (Mechanical, Administrative, General, and Electronics) yielded results consistent with those across all jobs. See Table 2. Mean aptitude and training performance were highest for Electronics jobs; mean variability in aptitude and training performance was lowest for Electronics jobs.

Table 3 summarizes the correlations among the study variables. All correlations were in the expected direction and were statistically significant at the $p \leq .0001$ level. Cohen (1988) characterizes correlations of .10 as small, .30 as medium, and .50 or greater as large. All correlations were in the medium to large range. Mean aptitude was negatively correlated with variability in aptitude ($-.759$) and with variability in training performance ($-.497$). That is, trainees in specialties with high mean aptitude were less variable on both aptitude and training performance. Mean aptitude was positively correlated with mean training performance (0.586), indicating that mean grades were higher for courses with higher aptitude trainees. Variability in aptitude as measured by SD , was positively correlated with variability in training performance ($.321$). When the CV relative measure of variability was used, the relationship was stronger ($.481$).

Table 2. Means and SDs for study variables by broad aptitude area

Variable	Mechanical $N_j = 29$ $N = 40,455$		Administrative $N_j = 4$ $N = 6,300$		General $N_j = 59$ $N = 54,945$		Electronics $N_j = 16$ $N = 14,610$	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AFQT Mean	67.57	3.80	55.47	3.04	68.21	10.32	76.23	4.63
% Corr. mean	88.83	1.09	87.61	1.06	86.53	3.62	89.89	1.35
AFQT CV	21.92	2.39	25.77	0.99	20.38	5.52	17.46	2.44
% Corr. CV	5.73	0.69	6.91	.41	6.25	1.59	5.05	.42

Note: N_j = number of jobs; N = number of trainees.

Table 3. Correlations of study variables

Variable	AFQT mean	AFQT SD	% Correct mean	% Correct SD	AFQT CV	% Correct CV
AFQT mean	1.000					
AFQT SD	-.759	1.000				
% Corr. mean	.586	-.343	1.000			
% Correct SD	-.497	.321	-.700	1.000		
AFQT CV	-.957	.904	-.525	.449	1.000	
% Corr. CV	-.534	.336	-.788	.990	.481	1.000

Note: All correlations are statistically significant at $p \leq .0001$. % Correct mean and % Corr. SD are measures of the dependent variable of training outcome. $N = 116,310$.

The greater variability in jobs with lower minimum aptitude requirements can be explained in this way. For jobs with high minimum aptitude requirements, there is a floor effect on aptitude. For jobs with low minimum aptitude requirements, there is less of a floor effect and less of a ceiling effect on aptitude. Although there is some effort not to place applicants in jobs for which they are highly overqualified, all jobs (even those with low minimum aptitude requirements), have some high aptitude trainees assigned to them. As discussed elsewhere in the paper, this is done, in part to ensure growth of leaders in each job. Further, a consequence of lower variability (more homogeneity) in aptitude for trainees in high minimum aptitude jobs is that they are less variable on training performance.

6. Conclusions

Personnel selection and classification into jobs is somewhat different for the private sector compared to the military. In the private sector applicants for a particular job often have specialized education, training, or prior experience. Although there are mean score differences in aptitude across jobs, variability within jobs tends to be small (Hoffman, 1995; Hunter, 1983; Linn et al., 1981; Sackett & Ostgaard, 1994; Schmidt et al., 1992). Military organizations are different. To begin, although they recruit personnel based on aptitude (i.e., trainability), they typically do not require applicants to have specialized education, training, or prior experience. As a result, trainees for a particular job tend to be more variable than in much of the private sector. In the military, the acquisition of job-related specialized knowledge and skills occurs during training. Although personnel with high aptitude tend to be assigned to difficult jobs with high aptitude requirements, some high aptitude trainees are assigned to each job. This is done to ensure that some personnel within each career field have a high probability for promotion and leadership development, thus sustaining the effectiveness of the career field. Further, a consequence of lower variability in aptitude for trainees assigned to jobs with high minimum aptitude requirements is that they are less variable on training performance. In addition, as hypothesized by Ackerman (1987) and Alliger and Katzman (1997), training has the effect of reducing variability in performance among trainees. This likely is the consequence of structured training courses that require all trainees to exhibit competence on all elements of the curriculum. In military technical training, specific levels of knowledge and skill proficiency are required for training success. This is important as training graduates advance to their first operational assignment; supervisors can expect new personnel to possess a common core of job-related knowledge and skills, thus facilitating the acquisition of

additional knowledge and skills that come with experience on the job.

Notes

1. The AFQT is a weighted composite of the standard scores, S , of the ASVAB Verbal (VE) composite (Paragraph Comprehension – PC and Word Knowledge – WK tests) and math tests (Arithmetic Reasoning – AR and Math Knowledge – MK) and is reported as a percentile score. $AFQT_S = S_{AR} + S_{MK} + 2S_{VE}$ (Segall, 2004). The minimum qualifying AFQT percentile score for the Air Force is 36.
2. The Air Force aptitude composites are: Mechanical (M) = AR + MC + AS + 2VE; Administrative (A) = MK + VE; General (G) = AR + VE; and Electronics (E) = GS + AR + MK + EI. The MAGE composites reflect four broad occupational groups.
3. The CV divides the standard deviation by the mean so that the two metrics cancel out leaving it metricless.

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